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Slushing Type Rust Preventives

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(Continued from March Issue)

F. Evaluation Tests

A number of evaluation tests may be conducted on slushing type rust preventives, namely: (1) actual performance, (2) exposure, (3) accelerated corrosion and adhesion, and (4) determination of essential physical and chemical properties. A product which meets these tests should prevent corrosion, should not affect the metal, should resist the corrosive influences without altering its own composition adversely, should be removable without injury to the metal it protects, should adhere to the surface under the conditions prescribed, should be applicable by standard methods, and should be economical. Sometimes additional characteristics are required of a rust preventive, such as ability to neutralize acidic substances, and to lubricate. Of the tests outlined above, the accelerated ones are the most popular particularly the humidifier and the fresh water spray.

For brevity, only a limited number of the evaluation tests will be described.

1. Actual Performance Test: An example of an actual performance test is given in Navy Specification 14-C-6a, Section F-3-(a)4. In this test, a submarine ballast tank is coated with the material under observation and also with a compound which has been tested and previously reported as satisfactory. The relative performance is determined after 9 months' actual service.

On land—Test made on a cold rolled premium grade polished steel rod 1½ inches in diameter, 6 inches long. This test piece was used for comparison with the weathered specimens. In a similar manner a number of other coatings were tested to ascertain how they would protect the steel outdoors and also whether the coatings adhered to the surface under these conditions. The same tests were repeated indoors.

2. Exposure tests under Ordinary Conditions:

On Land—Often evaluation of slushing compounds is made by exposure to the elements but not under actual operating conditions. For example, in Navy (Ships) 52-C-18 a ¾ inch diameter, 6 inches long, mild steel specimen is coated with a specified thickness of slushing compound, is air dried for 24 hours, and is exposed upright indoors for 50 weeks. Weathering of Grade II for six months and Grade III for four months in a shed is required by the same specification.

On Water—Another exposure test under ordinary conditions and unlike the service to which it would be put, was conducted by one company on marine slushing coatings. Hot roll steel plates 6′ x 13″ x ⅛″ were used. The edges were rounded and the total surface sandblasted. The panels are divided in three sections: the top, to simulate location of topside coatings on ship; the center, boot topping section; and the lower, where antifouling compositions are generally applied. Colored coatings were used to bring out the different sections clearly in the photographs. Actually, the slushing coatings used were not as distinctive. Some of the panels were halved vertically for application of two different combinations on the same section. The effect of the variation of the tides was intended to resemble the action of water on boats coated with slushing compounds. Much information may be secured from such a test, but it should be noted that this test is not conducted exactly under the same conditions as would be experienced by a boat operating in the same waters. The tests should be conducted through all seasons to approximate actual conditions.

3. Accelerated Corrosion and Adhesion Tests

(a) The Humidifier Test: Slushing compounds are generally evaluated by accelerated tests designed to be comparable to actual service conditions. Of these, the humidifier and fresh water spray tests are most commonly used.

The humidifier cabinet is made of a porcelain-lined 3-door used refrigerator in which 100% relative humidity and 100°F, temperature are maintained. Air is bubbled through distilled water at the rate required by vendor's specifications which is usually two complete air changes per hour. This represents 16 cubic feet per hour for the box illustrated. Constant level is maintained by a syphon from a bottle of distilled water on top of the cabinet. A 150-watt incandescent lamp immersed in the water is used to warm it. The temperature is controlled by a simple thermoregulator like the one shown in the picture. Observation of the temperature and humidity was made from a hygrometer in upper left portion of the box. The readings were visible from the glass door. The specimens were suspended from the glass hooks at the right of the cabinet. The size and type of panels used varied with the requirements specified by the purchaser. Sandblasted blue annealed panels 2″x4″x$\frac{1}{16}$″ have been found satisfactory in a number of tests.

After application of the slushing coatings, the panels are allowed to remain overnight to render them drip-free and then placed in the cabinet. The humidifier described should be well insulated, otherwise it will have a tendency to swell.

Humidifier evaluation tests are required in a number of Government specifications. For example, Army Specification 2-84B, Compound Rust Preventive, Light, requires that 2″x3″x18″ clean and polished plates with rounded edges made from cold rolled steel shall be polished, washed with wood

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FIGURE 23 PRINCIPAL GOVERNMENT SPECIFICATIONS — SLUSHING COMPOUND

Spec. No.	*Title of Specification*	*Uses of Products Covered by Spec.*	*Length of Service Expected*	*Approval on Lab. Tests*	*Service Tests*
ARMY 2-82-C (5-14-40)	*Compound, Rust Preventive* HEAVY (Solid) (Supersedes RIXS 120)	For highly finished metal surfaces, such as interior or recoil cylinders.	10 years	x	–
2-84-B (6-2-42)	*Compound, Rust Preventive* LIGHT (Semi-fluid)	For highly finished metal surfaces, *indoors.*	1 year	x	–
NAVY OS-627 (7-30-40)	*Gun Slushing Compound* Grade A (Solid)	For guns.	Service test required 1 year	x	x (1 yr.)
14-C5-A	See Maritime 52-MC-A-1				
14-C-4D (11-1-39)	*Compound, Rust Preventive* Type A, Non-Drying, HEAVY Grade I (Semi-Solid)	Protection under most severe conditions in all climates. Not suitable for interior of cylinder reduction gears or working parts of machinery. Does not reform its film.	Indefinite	x	–
	Grade II MEDIUM (Medium Heavy Liquid)	For working surfaces of machinery Reforms its film.		x	–
	Grade III LIGHT (Light Liquid)	For spraying blowers, castings and inaccessible places. Maintains complete film.		x	–
	Compound, Rust Preventive Quick-Drying. TYPE B (Medium-Heavy Liquid)	For protecting machinery and other metallic material which is handled frequently.	Temporary	x	2 Mos.
	Compound, Rust Preventive Non-Slick. TYPE C (Similar in properties to Type A (Grade I) (Semi-Solid)	For use on submarine ballast tanks.	Indefinite	x	–
14-C-6A (3-1-41)	*Compound, Rust Preventive* Pigmented TYPE A (Brushing Liquid)	For submarine ballast tanks.	Min. 9 Mos.	x	9 Mos.
	TYPE B (Solid)	For steel decking and embedded wood decking.	Indefinite	x	3 Mos.
NAVY (Ships) 52-C-18 (INT) (3-15-41)	*Compound, Rust Preventive* Thin Film—Polartype (Liquid) GRADE I	Corrodible metals exposed to outdoor weather conditions.		Shed Exposure 50 Weeks Outdoor Exposure	
Supersedes 14-C-7 (INT)	GRADE II	Corrodible metal where under cover storage is provided. On interior and exterior surfaces of all machinery and instruments and on all interiors of gasoline and diesel engines (except water jackets).		Shed Exposure 6 Mos.; 50 Weeks Outdoor Exposure	
	GRADE III	Corrodible surfaces on interior of machinery laid up under cover which, in normal conditions, are in contact with water or steam; and for displacing water and to inhibit further corrosion of machinery which has been submerged.		Shed Exposure 4 Mos.; 50 Weeks Outdoor Exposure	
MARITIME 52-MC-A1	*Compound, Rust Preventive* Grade A—Light (Liquid)	For protection of iron and steel in marine service.	1 year minimum	x	1 yr.
	Grade B—Medium (Liquid)	For protection of iron and steel in marine service.	1 year minimum	x	1 yr.
	Grade C—Heavy (Semi-Solid)	For protection of iron and steel in marine service.	1 year minimum	x	1 yr.
ARMY NAVY AN-VV-C-576 (12-30-41) Supersedes 3568E-M-367A	*Compound; Corrosion Preventive* Aircraft Engine (Liquid)	Additive for aircraft engine lubricating oil, for prevention of rust in aircraft engines and equipment.		x	–

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alcohol, rinsed with neutral absolute alcohol, dried in a desiccator, and dipped in the slushing compound at a maximum temperature of 150°F to give a film thickness of 0.015". The panels should then be drained while suspended in a vertical position. The plates are then maintained for 5 hours at 120-124°F and allowed to hang at room temperature for 24 hours. Finally the plates are suspended by means of glass hooks in a humidity cabinet, at 100% relative humidity at 100°F in which the air is changed from 2 to 2½ times each hour. To pass the test the slushing coating should not show any corrosion for 300 hours.

2. *The Fresh Water Spray:* The fresh water spray test is one of the two most popular accelerated corrosion and adhesion tests. This apparatus was adopted from U. S. Navy Specifications 14-C-4d. Water is dropped on the coating under test from a height of two feet intermittently, three minutes on and three minutes off, for a period of five hours. The water impinges the panels at an angle of 30°. The panels are made of polished steel 4"x6"x1/8". The compound is applied to the panels at 158°F and then maintained at 113-122°F. for 48 hours. Although five hours of the intermittent shower is required by the Navy 14-C-4d, many commercial slushing compounds exceed this requirement many times. This test is applied only to the heavier coatings which should withstand the scouring action of the intermittent shower.

3. See above.

4. *Miscellaneous Physical and Chemical Tests:* Besides the performance, weather and accelerated corrosion and adhesion tests, a number of physical and chemical tests are usually conducted on slushing type rust preventives. Some of the physical tests are drying, erosion, and film thickness. Among the chemical tests are mineral acid,

(Continued on page 4)

3. Other Accelerated Corrosion Tests:

Some additional corrosion tests not described above are tabulated below:

Title of Test	*Specification In which used.*	*Remarks*
Salt water immersion	AXS-674	3½% salt solution at 70-80°F
Combination salt water spray and weathering	14-C-4d	3% salt solution first day, weathering 5-60 days
Ultravoilet rays	2-82-C	Ultraviolet rays 5 hours each day for 7 days
Inverted watch glass	2-84-B	Partially coated steel plate covered with inverted watch glass and allowed to remain for 10 days
Acid vapor test		Steel coated plates coated with compound suspended over specified acid vapor which may or may not be heated
Accelerated burial test		Only for underground coatings. Steel panels placed in pit for specified period in which sandy loam containing 1% salt is mixed.

MISCELLANEOUS EVALUATION TESTS FOR RUST PREVENTIVES

Physical Tests

Title of Test	*Examples*	
Abrasives	2-82-C	F-2a
Absorption	14-C-6a	F-3b(2)
Drying	2-84-B	E-5
Erosion	14-C-6a	F-3a3
Film Thickness	52-C-18 (INT)	F-2g
Fire Point / Flash Point	14-C-6a	F-2i
Homogeneity	OS-627	Page 3
Melting Point	14-C-4d	F-2a
Penetration	14-C-4d	F-2j
Pour Point	14-C-4d	F-2a
Sagging	14-C-6a	F-3a(1)
Stability	2-84-B	F-4b
Solubility	AXS-674	F-8
Viscosity	AXS-674	F-1
Volatile Matter	AXS-674	F-4
Working Properties	14-C-6a	F-3b(1)

Chemical Tests

Acidity	2-82-C	F-2c
Chromate	OS-627	Pg. 5
Mineral Acid	2-84-B	F-4e
Neutralization Number	2-84-B	E-7a
Pigment Content	AC-3595	F-13
Rosin Content	2-84-B	F-4f

FIGURE 23 PRINCIPAL GOVERNMENT SPECIFICATIONS — SLUSHING COMPOUND — *(Continued)*

Spec. No.	*Title of Specification*	*Uses of Products Covered by Spec.*	*Length of Service Expected*	*Approved on Lab. Tests*	*Approved on Service Tests*
AIR CORPS AC-3595 (12-9-40)	*Compound; Slushing, Fuel Tank* (Liquid)	For prevention of corrosion in fuel tanks and to seal minute leaks. This compound may also be used over Zinc chromate primer.		x	–
ARMY ORDNANCE (Tent. Spec.) AXS-674 5-11-42	*Oil, Lubricating, Preservative* Medium (Liquid)	Prevention of corrosion internally and externally on engines, auxiliary parts (ferrous and non-ferrous metals) during storage.		x	–
AXS-702 7-10-42	*Oil, Lubricating, Preservative* Light (Liquid)			–	–

FIGURE 38
COMPARISON EVALUATION TESTS TYPICAL GOVERNMENT SPECIFICATIONS — RUST PREVENTIVES

	NON-DRYING					DRYING
	Unpigmented			Pigmented		
	Liquid Lubr. and Preservative	*Liquid Brushing Consistency*	*Plastic*	*Liquid-Spray or Brush*	*Plastic*	
Government Spec. No.	AXS-674	2-84-B	2-82-C	AC-3595	14-C-6A	14-C-4D
Date *	2-2-42	11-12-41	5-14-40	12-9-40	3-1-41	11-3-39
Title	Oil, Lube, Preservative, Medium	Compound, Rust Preventive, Light	Compound, Rust Preventive, Heavy	Compound, Slushing, Fuel Tank	Compound, Rust Preventive Pigmented, Type A	Compound, Rust Preventive, Type B Quick-Drying
Principal Evaluation Tests						
Actual Performance					9 Mos. Submarine Ballast Tank	2 Mos.
Exposure, Ordinary Conditions			30 Days -45°H. Lab. 30 Days, 45° V. to South-Outside			2 Mos.
Accelerated, Corrosion and Adhesion:						
Salt Water Immersion	3½% 70-80°F. 20 Hours			3% NaCl and Aircraft Fuel, Toluene, Alcohol, 7 days		
Humidifier	18 Hrs. Storage 130°F. 200 Hrs.	.015 in. Film oven 5 hrs. 120-124°F. Room Temp. 24 hrs. 100% Humidity 100°F. 300 hrs. 2-2½ Air Changes per hour.	100% 100°F. 7 days; 100% 100°F. 19 hrs.			
Fresh Water Spray					45° ¼ in. Steam 4 ft. min.	
Salt Water Spray					4% NaCl twice daily Horizontal 30 days	
Utra Violet Light			5 hrs. day, 7 days repeat 7 days.			

**For latest date of specifications see Figure 23.*

(Continued from page 3)

pigment content, and soluable chromate content.

Some purchasers of slushing coatings also require that the coating adhere to metal surfaces in vertical position at a designated temperature for five days or more. A more severe adhesion requirement is the Slick Test in which a coated stirrer is rotated at 1500 r.p.m. for 3 minutes in 4% salt solution at 100°F. Finally, another test for some slushing compounds is the determination of whether the compound will neutralize acid solution (0.1% H Br, aqueous) after four hours, for example AXS-674, oil, lubricating preservative, medium.

5. *Comparison Typical Evaluation Tests of Government Specifications for Rust Preventives:* As a convenience to the reader, some of the evaluation tests for typical Government rust preventives are given in Figure 38. The table in Figure 38 is arranged horizontally by the class of compound, for example whether, first, drying or nondrying; and, second, whether pigmented or unpigmented. An illustration of each of these types is given. Typical evaluations are supplied, such as performance, exposure and accelerated tests. Finally physical and chemical constants are given for the remainder of the evaluation tests. Each of the tests shown on this sheet was described under Section F. In short the table may be considered as a summary of all the principal tests described as applied to typical members of the slushing compounds.

6. *Correlation of Accelerated and Actual Performance Tests:* No evidence has been found to show that the life of a slushing coating is always comparable to its durability as determined by accelerated test methods. A number of slushing coatings have shown excellent durability by both accelerated and actual performance test; however, there are some coatings which have demonstrated superb characteristics by accelerated tests and have given poor actual performance. The ideal evaluation would be based on actual performance; however, frequently there is not enough time available to make the necessary tests. Moreover, actual performance may be too costly on account of the possible damages to the equipment on which the experiments will be made. Should it be feasible to make actual performance tests they should include a complete weather cycle and should also be repeated in a number of localities.

Attempts to reduce the time required for

(Continued on page 6)

FIGURE 38 *(Continued)*

COMPARISON EVALUATION TESTS TYPICAL GOVERNMENT SPECIFICATIONS — RUST PREVENTIVES

	NON-DRYING					DRYING
	Unpigmented			Pigmented		
	Liquid Lubr. & Preservative	*Liquid Brushing Consistency*	*Plastic*	*Liquid - Spray or Brush*	*Plastic*	
Governm't Spec. No. (For date and Title See Page 1, Fig. 38)	AXS-674	2-84-B	2-82-C	AC-3595	14-C-6A	14-C-4D
Principal Evaluation Tests						
Accelerated, Corrosion and Adhesion: *Miscellaneous*	Acid Neut. Property HBr Test. Race Corrosion	Inverted Watch Glass 10 Days	Combined Humidifier-19 hrs. and Ultra Violet 5 hrs. 7 days	After evaporation withstands change minus 40°F. 7 hrs. 212°F. 16 hrs. 5 times		
Other Tests						
A. Physical						
Abrasives		None	None			None
Drying		No drying, 120 hrs. Room Temperature	120 Hrs. Moving Air - None	3% Loss 7 days, 212°F.		No stickiness 3 hours
Melting Point			150°F. Min.		140-180°F.	
Penetration @ 77°F.		275 Unworked	60-90		40-60	Liquid
Pour Point	20°F. Maximum					
Solubility	Soluble Aviation Engine Oil 70-80°F.	Soluble Cleaner's Naphtha	Soluble-Kerosene	Insoluble Hydrocarbons. Soluble ETAc.		Soluble-Kerosene
Stability		No Separation 200-210°F. 1 hr.	Stable at 225°F. No separation 1 yr. at room temp.		230°F. to M.P.	
Viscosity	60-70 @ 210°F.		Liquid for dipping 180°F.	1½ Poises @ 77°F.		
Volatile Matter	2% 4 hrs. Steam Bath	1% 207-218°F. 1½ Hour		60-70%		
B. Chemical						
Pigment Content				1.2 ZnO, 1.5 CrO_3 } of N.V.	20-25% Blue Lead-Red Lead	
Soluble Chromate				–Yes	0.2%	

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(Continued from page 4)

evaluation of slushing coatings has led to the creation of a number of accelerated corrosion tests. Each of these tests was designed to simulate actual conditions which the coating may have to encounter. The humidifier, the water sprays, salt and fresh water, and adhesion tests have all been devised to duplicate actual service conditions. It has been assumed by many that since these tests were designed to compare with actual performance conditions that the results obtained from these evaluations would be comparable to the natural rate of corrosion. Often this assumption has been found wrong. Humidifier and spray

tests as well as a few other tests have become so well known among purchasers of slushing coatings that they have been made standards for acceptance tests.

G. Conclusion

This report has reviewed the subject of slushing type coatings in accordance with the detailed outline shown on Page 1. Illustrations used to bring out the important topics are listed in the first page of the Appendix. The development work on slushing compounds to date as far as we could determine from the literature available to us has been limited and of an experimental nature. More emphasis has been made on meeting Government specifications and matching competitors products than on determining the fundamental principles of the nature of effective slushing coatings. Industry would be aided materially by a more scientific investigation of slushing compounds.

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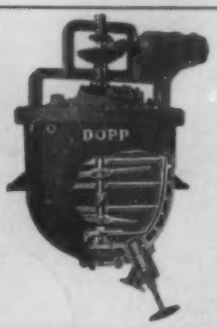

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